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Dynamic of pollutants concentration in forest stands from Copșa Mică industrial area

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Abstract. The paper presents the dynamics of pollutants concentrations from non-ferrous metallurgical plant in Copşa Mica, considered, between the years 1985 - 1989, as the most polluted area, even in the world, and detected as a large black spot on Landsat satellite imagery. Returning to investigations in this area, after 20-25 years, the pollution activity was changed after 1990, as a consequence of the reduction of industrial capacity, including the black smoke plant decommissioning, and the chimney built for exhaust pollutants over 350 m feet high, resulted some conclusions, necessary for decisions that have to be taken by environmental, forestry, health and agriculture authorities.The litter, soil and vegetation samples were colected from the same permanent sample plots between the years 2006-2009, as between the years 1985-1989, using the same methods, in order to be compared and analyzed. Therefore, returning to investigations in these permanent sample plots, were found the following conclusions: i) between the period 1985 - 1989, in all examined cases were revealed high pollutants concentrations, even exceeding the maximum allowable limit (MAL) consisting of suphur compounds in synergistic action with heavy metals (Cu, Pb, Cd, Zn, Mn, etc.), in vegetation and litter, which was directly correlated with noxious concentrations in the air, and concentrations below MAL in soil samples; ii) contrary, regarding the new pollution activity, it has been revealed low noxious concentration, in vegetation, litter and soil samples collected during the period between the years 2006-2008, which are directly related to their low concentration level in the air. Due to pollutants accumulation phenomenon over the years, high pollutants concentrations, ten times higher than MAL, were found in the superior soil layer. In such circumstances the best solution to protect the environment, population and livestock of the damaged area, for tens of thousands of hectares, is the closure of pollution sources, continuing ecological reconstruction works, already carried out on about 500 hectares of degraded land, unfortunately unsuitable for other uses-only for forestry fields, followed by vigorous action of soils decontamination, based on extensive interdisciplinary research.
Keywords: pollutants concentration, maximum allowable limit, heavy metals, Copşa Mică, decontamination.

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Introduction

The forests are subject of increasing anthropogenic impacts, especially regarding the pollution's effects on the environment.

This paper aims to present the dynamic of pollutants concentration, based on sulphur compounds, in synergistic action with heavy metals (Pb, Cu, Cd) in forest stands of Copşa Mică area, between 2006 - 2008 comparing to 1986 - 1988 period.

In this period important changes occurred in the noxious regime, determined on one hand by reducing of the industrial activity, even closing some industrial capacities - for example the carbon black factory Carbosin, on the other hand, the construction of the pollutants exhaust chimney high above 350 m, by dispersing them over large areas.

Regarding the pollutants, the following comments could be made. Closing the factory of carbon black smoke Carbosin, in 1990's, it was made the assertion that the pollution problem was solved in the area of Copşa Mică, even in present when the plant SOMETRA SRL continues to operate the metallurgical processing of nonferrous metals. It is well known that the carbon black smoke did not act on vegetation by burning rapidly the plant tissue as sulphur compounds did, eventually the black smoke can contribute to enhance the action of sulphur compounds in synergistic action of them, or through a mechanical seal running of the stomata with implications in photosynthesis reduction (Ianculescu et al. 1989). Therefore, the most aggressive action on forest ecosystems is the pollution-based on sulphur compounds in synergistic action with heavy metals (Pb, Cu, Cd, Zn, Mn).

The construction of high chimneys, over 350 m high, in order to exhaust the pollutants, accredited also the idea of solving the problem of pollution. The area near to the source of pollution has a certain protection in these conditions, offering the possibility of achieving, with rather high costs, of ecological reconstruction works, as it has already been achieved in the area Copşa Mică (Alexa et al. 2004, Ianculescu 2005). Nevertheless, the exhaust of pollutants is made on large areas, contributing in time, through the accumulation of pollutants in plants and soils, to increase the concentrations with major adverse implications on the environment, as shown also in this paper.

Materials and methods

The samples of vegetation, litter and soil were harvestedin 2006-2009 from the same permanent plots, established in 1986, in forest stands under the influence of pollution from the industrial area Copşa Mică and analyzed by the same methods, as follows:

- Soil samples: pH in water suspension; the organic matter by Walkley - Black's method, Gogoaşă modification; sulphur as SO_4^{2-} in water extract; extractable Aluminium - by Coloman in KCl 1n, texture pipette's method : soluble P and K by method of Egner Riem Domingo (double ammonium lactate); mobile Ca and Mg NaCl 0.5 n in flamphotometric; total N using Kjeldhal's method; heavy metals (Cu, Pb, Zn, Cd, Mn) as total prescribed amounts and soluble forms by spectrophotometer's method with atomic absorption, total forms of chloral acid solution obtained after decomposing with a mixture of strong acids (NHO_3, H_2SO_4, $HClO_4$) and soluble metals by extraction (Cu, Zn and Mn in DTPA, pH 7.3, and Pb and Cd in CH_3COOH, 0.5 H.
- Dried vegetation samples: heavy metals (Cu, Pb, Zn, Cd, Mn) by the method of spectrophotometer atomic absorption; sulphur as SO_4^{2-} granulometric methodş N by Kjeldahl's methodş P and K using Egner Riem Domingo's methodş Ca and Mg flamphotometric

Results and discussion

Table 1 shows the characteristics of permanent plots from Copşa Mică area established between 1984 - 1987, and the biometric data of forest stands in the year 2007. In Figure 1 is presented the map of forest stands affected by industrial pollution, with damaged zones from Copşa Mică, on different levels of intensity, in the year 1987.

The Tables 2 - 7 and the Figures 2-12 present the dynamics of pH and concentrations of sulphur compounds (SO_4), heavy metals (Pb, Cu, Zn, Cd) in the Ao soil layer from vegeta-

Table 1 Forest stands characteristics in sampling permanent plots from Copşa Mică industrial area (2007)

Fores District	Management unit U.P.	Com-partment u.a.	Distance to pollution source -*km*-	Main tree species	Regene ration stand type	Standage	Number of trees per hectare	Basal area per hectare	Mean diameter of the main tree species	Medium height of the main tree species	Density index	Site class	Volume per hectare *V.ha*$^{-1}$ m3.ha^{-1}	Damaged zone *
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Mediaş	I. Seica Mică	12C	7,5	Sessile oak	S	135	283	29,0	46,6	25,5	0,72	III	361	2
		17A	7,3	Sessile oak	S	95	256	25,6	38,4	23,2	0,71	III	320	2
		17As	6,0	Sessile oak	L	95	355	31,0	43,1	20,8	1,1	III	557	2
		18B	5,9	Sessile oak	L	125	612	41,2	33,0	21,0	1,2	III	461	3
		25F	9,0	Sessile oak	L	105	461	31,4	29,4	23,9	0,94	II	410	3
		27C	9,4	Sessile oak	L	100	670	49,1	31,3	23,3	1,5	II	615	3
		30B	7,5	Sessile oak	L	105	369	33,7	36,2	26,4	1,0	II	459	3
		37B	17,0	Sessile oak	L	80	518	27,2	25,9	17,2	1,2	IV	257	4
		10A	6,0	Common beech	S	100	203	34,4	46,5	28,4	0,87	II	456	3
		19C	6,6	Common beech	S	100	165	39,3	55,0	31,6	0,99	II	595	3
		2D	4,2	European black pine	P	95	389	31,8	35,4	23,8	0,70	II	315	1
		3A	4,6	European black pine	P	95	797	51,9	31,8	23,0	1,14	II	502	1
	II. Micăsasa	72B	13,1	Sessile oak	L	75	408	30,3	30,7	23,5	1,0	II	389	2
		75B	14,0	Sessile oak	L	80	238	19,8	34,2	22,9	0,6	II	247	2
		97A	11,1	Sessile oak	L	70	558	30,9	27,2	22,4	1,0	II	377	2
		104F	12,0	Sessile oak	L	80	653	30,4	29,0	25,0	0,75	I	378	2
	II. Micăsasa	108B	9,5	Sessile oak	L	75	369	28,1	31,7	22,3	0,88	II	341	2
		111B	10,5	Sessile oak	L	80	422	32,0	32,3	20,1	1,1	III	354	2
	III.Târnava	16D	3,0	Sessile oak	L	70	365	2,6	43,0	16,9	0,87	III	203	2
		39B		Sessile oak	L	115	227	26,0	44,5					2
		20B	6,8	Common beech	S	115	200	30,9	44,4	30,8	0,75	II	470	3
	IV.Boian	21B	6,5	Common beech	S	110	143	31,0	52,6	35,7	0,69	I	559	3
		17A	11,5	European black pine	P	95	585	33,3	26,9	18,3	0,80	III	262	4
	VII.Moşna	17A	11,5	Scots pine	P	95	385	33,0	33,0	20,4	0,75	III	275	4
		53A	12,8	Common beech	S	110	162	25,3	44,6	29,7	0,62	II	365	4
		53C	13,0	Common beech	S	110	280	37,6	41,4	28,1	1,02	III	504	4
		54A	12,6	Common beech	S	95	197	27,8	42,4	32,4	0,64	I	438	4

Table 1 (continuation)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	VIII.Valea Viilor	6A	4,6	Sessile oak	S	115	154	19,0	44,6	31,5	0,4	I	281	2
		21C	5,4	Sessile oak	S	100	204	18,8	37,7	23,8	0,58	III	238	2
		20C	5,0	Common beech	S	110	231	43,6	50,1	32,7	1,01	I	612	2
		46G	5,8	Common beech	S	100	280	32,2	38,3	35,5	0,73	I	578	3
		48A	6,2	Common beech	S	90	253	32,4	40,4	35,2	0,76	I	561	3
Dumbrăveni	I.Dumbrăveni	80A	31,0	Common beech	S	100	304	35,9	38,8	29,4	0,91	II	514	3
	V.Biertan	4A	24,2	Common beech	S	115	238	32,4	41,7	39,8	0,71	I	607	4
		5D	25,0	Sessile oak	S	115	549	44,8	40,0	30,2	0,96	I	654	4

*) 1 – very strong polluted; 2 – strong polluted; 3 – moderately polluted; 4 – low polluted (witness)

S = from seed; L = from seedlings; P = plantations

tion and litter, in the forest stands under the influence of pollution from the industrial area of Copşa Mică.

Comparing the results from the year 1987 with those from 2006, after almost 20 years, the resulting conclusions are very interesting. Therefore, if at the litter samples, especially in the growing season, there is a decrease of pollutants concentration, which it is consistent according the air concentrations (Table 8), in the Ao soil layer from those forest stands, there is a tenfold increase in these pollutants. This is the result of an annually accumulation in forest soils of the concentrations of pollutants in vegetation and litter, even if they are apparently lower comparing them to the values recorded in the year 1987. Same features are found in the dendrocronological research (Ianculescu et al. 2008). As result, the forest soils and trees have important deposits of pollutants, by aggregation and accumulation in the environment. The conclusion shows: in order to prevent and combat environmental pollution, we must protect two very important environmental factors: soil and forest vegetation.

There is also a correlation of the soil acidity (pH value), presented in Table 4, with the descending trend in concentrations of sulphur dioxide during the period 1989 - 2003 (Table 8 and graph in Figure 13). These results are useful in the ecological reconstruction of Copşa Mică forest ecosystems in the area.

We can notice the current high levels of Cadmium, both in the OH soil layer and vegetation samples and litter, even at great distances from the source of pollution (Tables 5 - 7 and Figures 8 - 10). This is extremely worrying because it is known that overrunning the maximum allowable limits (MAL) to Cadmium is carcinogenic.

Conclusions

After the integration in the European Community, it is compulsory to our country to meet new economic conditions and environmental requirements. Therefore, it is necessary to monitor the pollution, with its influence on the environment. The investigations

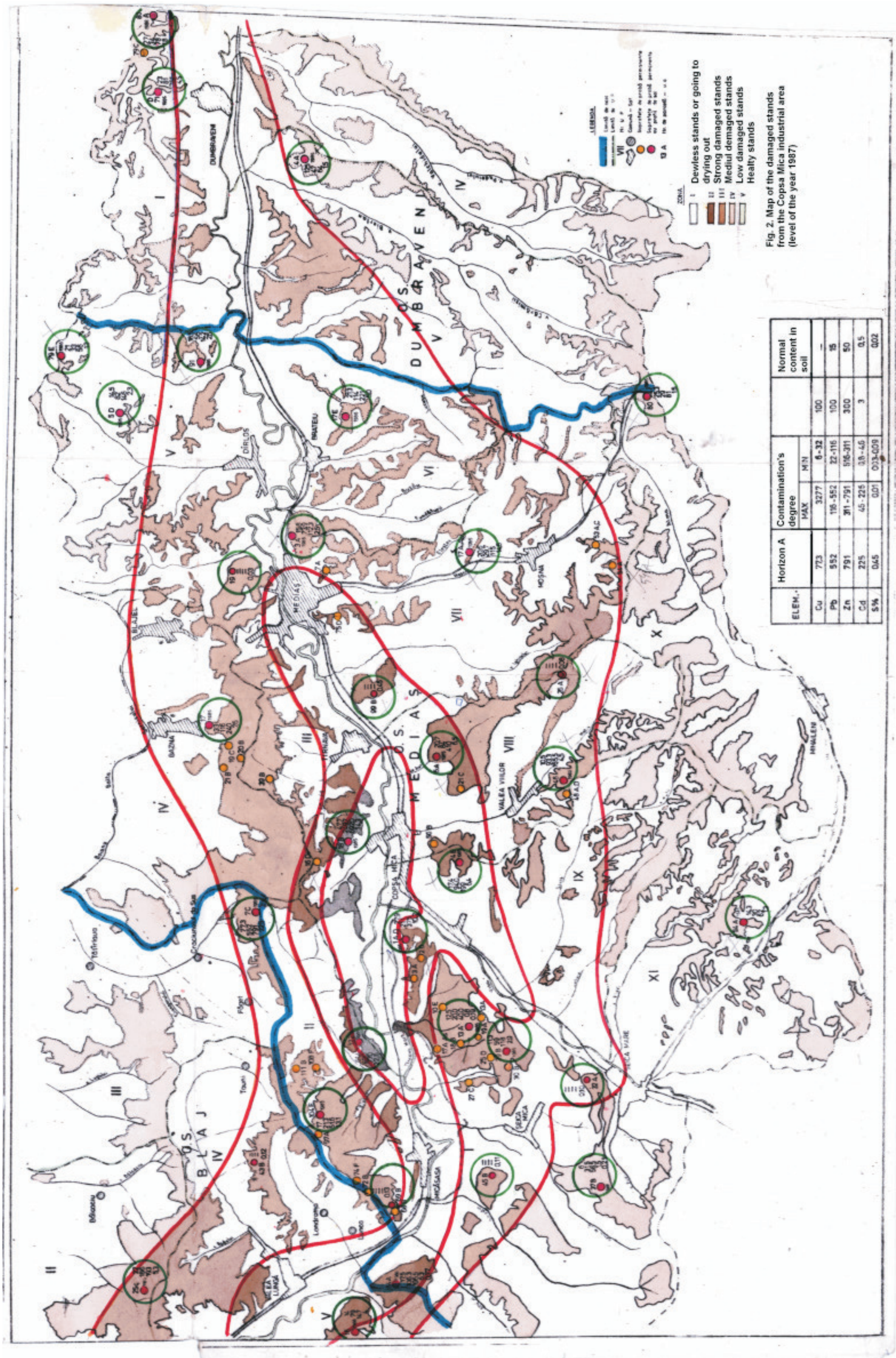

Figure 1 The study area and the location of sample plots

Table 2 Dynamics of pH and heavy metals concentrations (Pb, Cu, Zn) in Ao soil's layer of the forest stands from Copşa Mică industrial area

Management unit U.P.	Compartment	Distance to pollution source 12 km	pH		Heavy metals concentration, in ppm					
			1985	2006	Pb, total		Cu, total		Zn, total	
					1987	2006	1987	2006	1987	2006
1	2	3	4	5	6	7	8	9	10	11
I	1A	3,0	4,32	3,9	211,0	6663,0	27,9	458,3	375,0	1560
	13A	7,0	4,2	5,2	20,0	453,4	12,5	52,3	40,0	271,4
	30A	7,5	4,6	5,5	59,1	362,5	11,3	49,0	118,6	235,0
	37B	17,0	5,3	5,2	31,5	252,1	6,0	36,6	58,5	126,2
	84A	14,0	4,0	4,3	106,0	978,1	17,5	92,7	197,0	485,1
II	104F	12,0	4,4	4,9	21,3	493,6	16,9	51,5	51,6	273,8
	122C	6,5	3,8	3,7	490,0	2086,0	61,4	186,6	770,0	780,5
III	17A	2,0	3,95	5,8	116,0	4262,0	33,0	467,4	240,0	1672,0
	18B	1,8	4,0	4,2	249,7	924,5	47,7	415,9	692,0	1097,0
IV	17E	16,0	4,4	5,5	114,0	295,0	21,3	466,7	221,0	265,3
V	79E	22,0	7,0	5,5	33,0	269,3	21,0	64,2	56,0	173,6
	91E	17,0	5,3	5,9	56,0	258,7	18,5	55,6	142,0	174,7
VII	3A	17,0	4,1	3,1	73,9	1103,0	15,8	127,1	112,3	446,3
	46A	6,0	4,2	5,3	93,3	543,9	10,5	64,2	156	309,3
	99B	5,0	3,7	4,3	1116,0	4069,0	463,0	271,3	1148	983,1
VIII	46A	6,0	4,2	5,3	93,3	543,9	10,5	64,2	156,0	309,3
IX	4E	3,0	4,3	4,2	94,0	1659,0	17,4	16,7	199,0	1339,0
VIII	6A	3,6	5,8	4,6	84,0	1000,0	20,7	81,9	410,0	475,6

Table 3 Dynamics of heavy metals (Pb, Cu, Zn, Cd) in litter and vegetation in some of the forest stands from Copşa Mică industrial area

Management unit U.P.	Com-part-ment	Distance to pollution source 12 km	Litter						Vegetation							
			Concentrations in ppm						Concentrations in ppm							
			Pb		Cu		Zn		Pb		Cu		Zn		Cd	
			1987	2006	1987	2006	1987	2006	1987	2006	1987	2006	1987	2006	1987	2006
I	30A	7,5*	371,0*	62,2	34,9	10,8	490,0	472,0	52,8	3,3	18,4	5,7	97,6	41,1	0,9	1,2
			96,0	49,7	27,4	21,0	330,0	562,0								
	84A	14,0*	1055,0	195,8	73,0	5,7	501	2011,0	469,0	9,1	28,6	4,0	430,0	79,0	1,6	1,6
			3001,0	367,7	252,0	127,3	537	2409,0								
II	104F	12,0	1472,0	179,7	113,0	37,1	1652,0	1280,0	111,0	6,0	26,3	7,5	215,0	67,1	1,6	1,3
			1262,0	210,0	98,0	59,4	1410,0	1726,0								
	122C	6,5	3550,0	389,4	805,0	121,9	2010,0	2600	356,0	15,6	36,9	5,8	580,0	72,8	3,6	1,9
			3510,0	656,0	438,0	270,9	1790,0	2710								
III	18B	1,8	2720,0	577,0	575,0	196,5	1850,0	2994,0	555,0	28,2	70,1	8,3	800,0	149,4	4,1	3,6
			2020,0	1080,0	415,0	402,3	1810,0	3488,0								
IV	17E	16,0	499,0	61,9	11,0	10,5	481,0	358,0	16,0	3,0	9,4	6,4	40,0	28,6	0,5	0,8
			-	157,8	-	40,5	-	963,0								
V	79E	22,0	8,0	2,1	19,3	1,3	32,0	159,0	6,3	2,1	10,4	6,2	28,0	25,3	0,5	0,8
			-	9,6	-	1,4	-	196,0								
	91E	17,0	146,0	36,9	11,0	7,5	547,0	268,0	35,0	2,4	11,0	5,1	61,0	35,4	0,6	0,8
			-	58,9	-	20,6	-	314,0								
VII	3A	17,0	1620,0	294,7	116,0	130,0	1450,0	2194,0	143,0	5,3	34,2	4,7	145,0	46,1	1,6	1,3
			663,0	-	74,8	-	698,0	-								
VIII	6A	3,8	1380,0	408,7	56,5	109,0	1480,0	2386,0	22,0	4,2	5,1	31,4	106,0	28,5	0,5	0,7
			350,0	202,6	96,0	64,9	920,0	1666,0								
	46A	6,0	146,0	129,9	11,0	15,6	547,0	951,0	35,0	2,7	11,0	2,2	61,0	25,5	0,6	0,6
			-	323,9	-	54,2	-	2029,0								
IX	4E	3,0	1850,0	332,3	145,0	85,2	1600,0	2292,0	72,0	7,4	25,2	107,2	206,0	46,7	1,1	1,1
			835,0	673,3	111,0	208,3	1400,0	2939,0								

* $\frac{371.0}{96.0}$ ■ $\frac{0l_1}{0l_2}$ ■ $\frac{decomposedleaves}{undecompseleaves}$

Table 4 Dynamics of SO4 concentration in vegetation and litter in the forest stands from the Copşa Mică industrial area

Forest District	Management Unit	Compartment	Distance to pollution source	Main Tree species	Concentration of SO^{2-}_4 in vegetation, in ppm		Concentration of SO^{2-}_4 in litter, in ppm	
					1987	2007	1987	2007
1	2	3	4	5	6	7	8	9
Mediaş	II	18B	1,7	Sessile oak	0,70	0,35 (fag)	0,65 0,73	0,21 2,9
	IX	4E	2,8	Sessile oak	0,51	-	0,47 0,23	0,18 2,2
	I	1A	3,0	Sessile oak	0,74	-	0,64 0,53	0,27 -
	VIII	6A	3,8	Sessile oak	0,57	0,31 (carpen)	0,38 0,27	0,22 0,18
	II	122C	6,0	Sessile oak	0,78	0,16 (carpen)	1,09 0,65	0,20 0,20
	I	30B	7,5	Sessile oak	0,40	0,14 (carpen)	0,30 0,26	0,11 0,10
	VII	17A	11,5	Scots pine	0,40	-	0,34 0,31	0,01 4,9
	II	104F	12,0	Sessile oak	0,44	0,25	0,46 0,44	0,16 0,22
	VII	3A	17,0	Scots pine	0,49	0,22 (carpen)	0,45 0,42	0,16 -
	I	37D	15,0	Sessile oak	0,29	0,20	0,23 -	- 0,10
	VII	46	6,0	Common beech	0,33	0,17	0,32 -	0,08 0,13
	IV	17E	8,0	Scots pine	0,27	0,15 (gorun)	0,29 -	0,11 0,19

* *0,65 / 0,73 = undecomposed litter's concentration / degraded litter's concentration*

undertaken more than two decades ago have emphasized the ecological disaster produced, especially in the area of Copşa Mică, the existence of high concentrations of pollutants, higher tenfold even a hundred times than the maximum allowabled limit .

This ecological disaster could be detected as a large black stain on the satellite pictures taken in the year 1986 (Figure 13-14). Today, the Copşa Mică area is presented as a clean area (Figure 15) in the UN Atlas of The World Environment Day. This is due to the Romanian foresters' efforts, and especially those from Sibiu, for the environmental reconstruction of the most damaged areas from the ecological point of view (Ianculescu 2005).

Additionally, the ecological reconstruction performed on about 490 hectares, of which about 310 hectares in the forest and the rest outside the forest area (Alexa et al. 2004) couldn't be possible without the hard work of researchers and engineers of Forest Research and Management Institute, that provided scientific solutions, in order to achieve an ecological reconstruction

These efforts shall be continued because there are large areas of degraded lands, located outside the forest, which cannot be recovered only by forestry means. Even if the concentrations of air pollutants comply in general within the MAL, the fact that they accumulate pollutants over time in the Ao soil layer in high concentrations, they become extremely toxic to any life form. If we keep in mind the fact

Table 5 Dynamics of heavy metals concentrations (Pb, Cu, Zn, Cd) in the soil layer (OH)of the forest stands of some of the permanent plots, from the Copşa Mică industrial area

Forest District	Management unit U.P.	Compartment u.a.	Distance to pollution source km	Heavy metals concentration, in ppm							
				Lead (Pb) total		Copper(Cu) total		Zinc (Zn) total		Cadmium (Cd) total	
				1987	2008	1987	2008	1987	2008	1987	2008
Dumbrăveni	I	80A	24,0	34,00	59,00	27,30	15,00	78,00	407,00	1,8	4,06
		79C	25,0	-	4,50	-	15,50	-	266,75	-	5,18
	V	4A	25,0	47,00	1,25	12,50	15,00	64,00	526,75	1,50	11,17
		5D	25,5	-	3,25	-	13,50	-	149,25	-	4,84
Blaj	III	7C	6,0	552,00	565,75	77,3	35,50	791,00	695,50	22,5	19,19
	IV	25C	18,0	186,00	1571,00	22,00	60,75	193,00	836,25	5,30	7,56
	V	18	19,0	79,00	708,50	14,00	39,00	147,00	760,25	4,00	17,88
Mediaş	III	16D	1,9	249,7	257,00	47,7	29,50	692,00	566,75	14,30	30,75
		39B / 18B	0,3		232,50		19,00		559,75		9,90
	P.A. Târnăvioara	Improvement's area	0,3		2,00		13,75		168,50		72,75

Table 6 Dynamics of heavy metals concentrations (Pb, Cu, Zn, Cd) in litter of some of permanent plots from Copşa Mică industrial area

Forest District	Management unit U.P.	Compartment u.a.	Distance to pollution source km	Heavy metals concentration, in ppm							
				Lead (Pb) total		Copper(Cu) total		Zinc (Zn) total		Cadmiu (Cd) total	
				1987	2008	1987	2008	1987	2008	1987	2008
Dumbrăveni	I	80A	24,0	138,0*	82,75	17,5	20,50	219,0	327,50	2,75	2,83
				-	39,25	-	18,75	-	306,25	-	6,52
	V	4A	25,0	143,0*	2,00	17,1	11,25	245,0	71,00	2,9	6,77
				100,0	2,25	19,4	13,50	275,0	200,00	2,9	11,17
Blaj	III	7C	6,0	757,0	403,50	66,0	31,25	893,0	640,0	13,0	14,21
				1256,0	458,25	68,0	33,25	1093,0	673,0	16,0	93,25
	IV	25C	18,0	395,00	767,00	20,75	61,50	315,0	692,25	3,25	4,54
				444,00	536,25	25,10	34,75	350,0	659,50	10,25	7,78
	V	18	19,0	759,0	545,25	27,8	100,50	503,0	815,50	5,12	8,55
				921,0	572,75	49,6	34,00	713,0	649,50	12,80	17,70
Mediaş	III	16D	1,9	2720,0	905,0	575,0	50,75	1850,0	728,50	91,4	35,75
				2020,0	403,25	415,0	40,50	1810,0	642,75	58,9	118,8
	P.A. Târnăvioara	Improvement's area	0,3	-	4,25	-	11,50	-	3,50	-	250,3
					1,25		11,75		29,25		321,3

* undecomposed leaves / degraded leaves

Table 7 Dynamics of heavy metals concentrations (Pb, Cu, Zn, Cd) in OH soil layer of the forest stands of some of the permanent plots, from the Copşa Mică industrial area

Forest District	Management unit U.P.	Compartment u.a.	Distance to pollution source km	Main tree species	Heavy metals concentration, in ppm							
					Lead (Pb) total		Copper(Cu) total		Zinc (Zn) total		Cadmiu (Cd) total	
					1987	2008	1987	2008	1987	2008	1987	2008
Dumbrăveni	I	80A	24,0	common beech	19,0	1,75	10,4	14,50	60,0	89,25	0,75	0,60
				commom hornbeam	18,0	12,75	11,3	12,00	62,0	97,75	1,00	1,21
	V	4A	25,0	common beech	11,4	2,00	13,5	11,25	54,0	71,0	0,50	0,69
		5D	25,5	sessile oak	9,6	1,25	10,4	11,50	43,0	3,50	0,63	0,27
				pedunculate oak	-	1,25	-	11,75	-	29,25	-	0,29
				common hornbeam	22,0	4,50	5,8	15,50	74,0	266,75	0,75	1,48
Blaj	III	7C	6,0	sessile oak	103,0	30,25	12,0	13,00	153,0	243,25	1,40	1,39
				common beech	-	62,25	-	12,00	-	390,75	-	3,54
				common hornbeam	-	52,75	-	12,75	-	286,75	-	2,21
	IV	25C	18,0	sessile oak	37,4	2,00	11,0	10,75	50,0	47,75	1,00	0,50
				common beech	-	6,50	-	12,25	-	174,00	-	0,87
				common hornbeam	-	35,25	-	11,25	-	233,50	-	1,49
	V	18	19,0	pedunculate oak	66,0	22,75	13,5	11,75	63,0	172,75	1,50	1,02
				sessile oak	-	16,75	-	17,75	-	143,50	-	0,92
Mediaş	III	16D	1,9	sessile oak	555,0	174,25	7,01	20,75	800,0	513,50	4,10	4,49
				common hornbeam	575,0	232,50	59,6	19,00	705,0	559,75	5,95	5,78
		Improvment's area	0,3	canadian poplar	-	545.25	-	100.50	-	815.50	-	60.02
				Eleagnus angs.	-	572.75	-	34.00	-	649.50	-	14.25
				Salix fr.	-	708.50	-	39.00	-	760.25	-	64.50
				Acer neg.	-	403.50	-	31.25	-	640.00	-	9.80
				Catalpa	-	458.25	-	33.25	-	673.00	-	18.60
				Aaesculus hip.	-	565.75	-	35.50	-	695.50	-	17.50
				Robinia ps.	-	536.25	-	34.75	-	659.50	-	14.60
				Salix alba	-	1571.00	-	60.75	-	836.25	-	1.32
				Ailanthus	-	767.00	-	61.50	-	692.25	-	16.38
				Fraxinus ornus	-	905.00	-	50.75	-	728.50	-	20.50

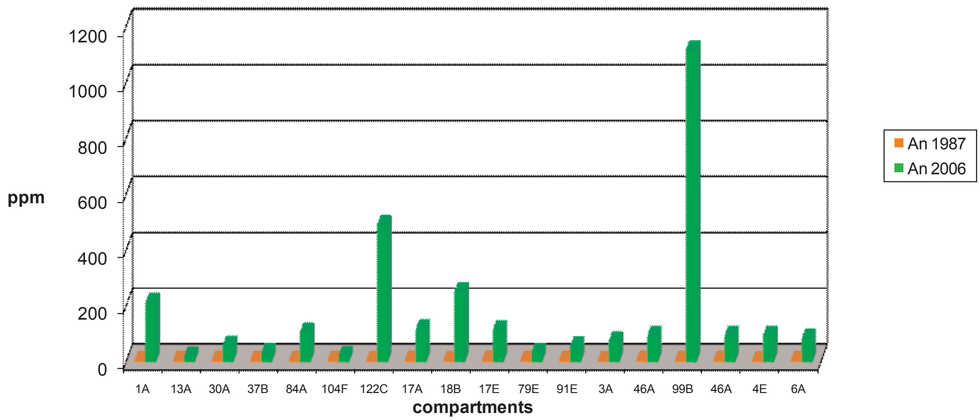

Figure 2 Dynamics of Pb concentration in the A0 soil layer of the forest stands from Copşa Mică industrial area

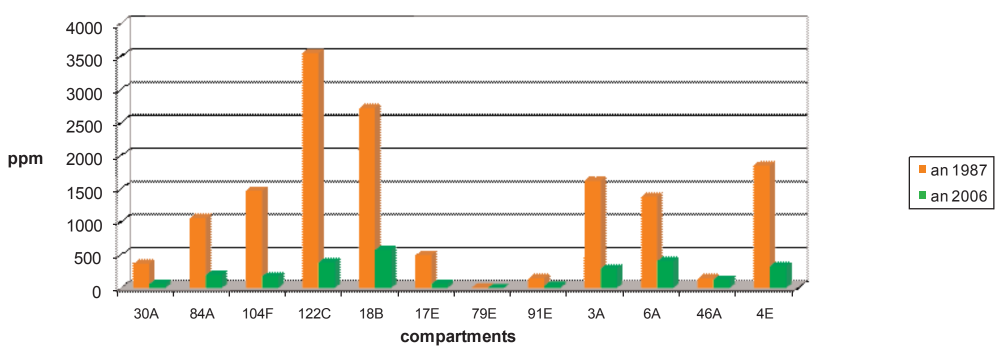

Figure 3 Dynamics of Pb concentration in the litter layer of the forest stands from Copşa Mică industrial area

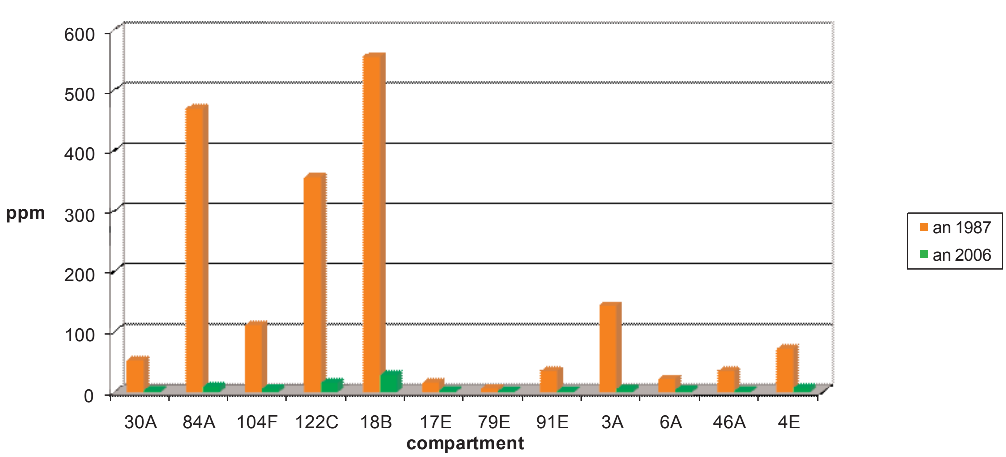

Figure 4 Dynamics of Pb concentration in the trees foliage of the forest stands from Copşa Mică industrial area

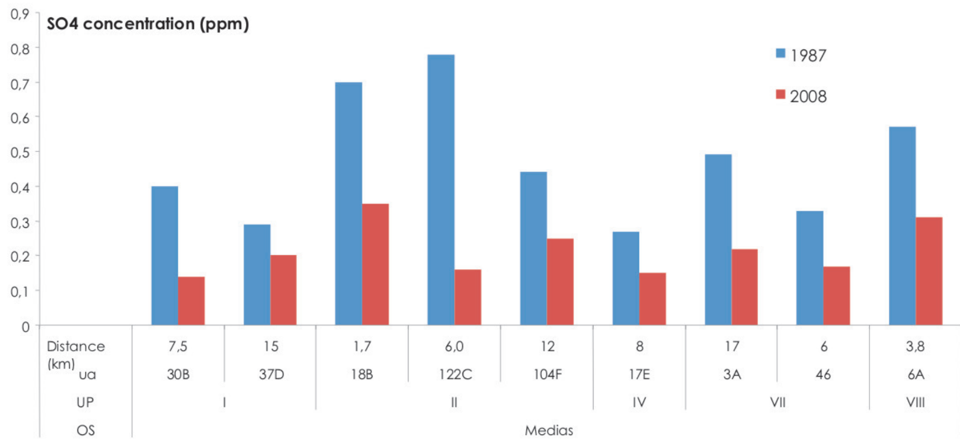

Figure 5 Dynamics of SO_4 concentration in vegetation of the permanent sample plots in the Copşa Mică industrial area

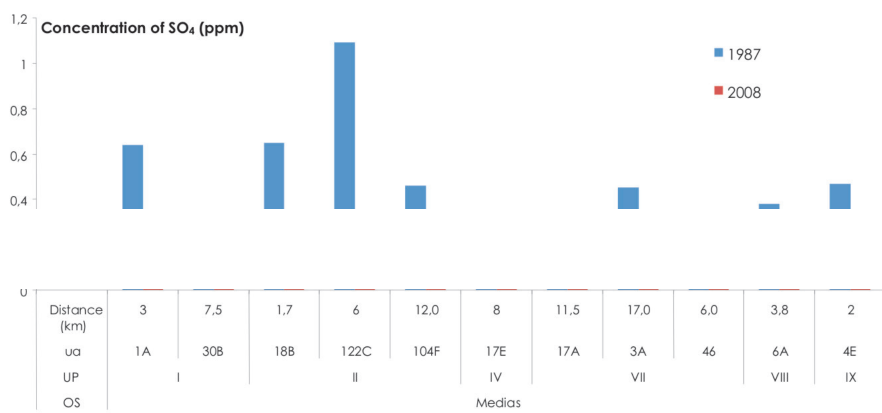

Figure 6 Dynamics of SO_4 concentration in litter of the permanent sample plots of the Copşa Mică area

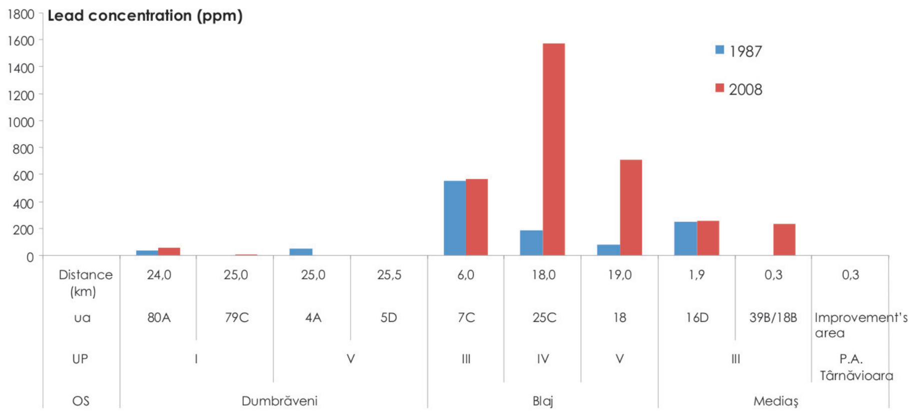

Figure 7 Dynamics of total lead concentration in OH soil layer of the permanent plots from Copşa Mică industrial area

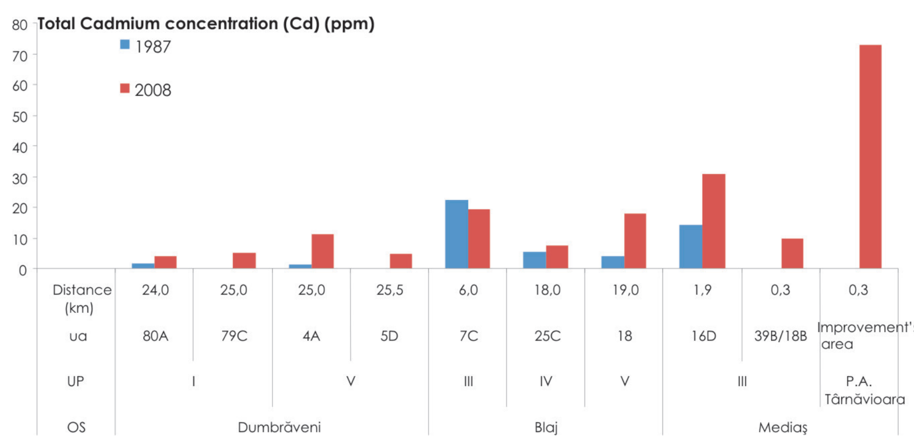

Figure 8 Dynamics of total cadmium concentration in OH soil layer of the permanent plots from Copşa Mică industrial area

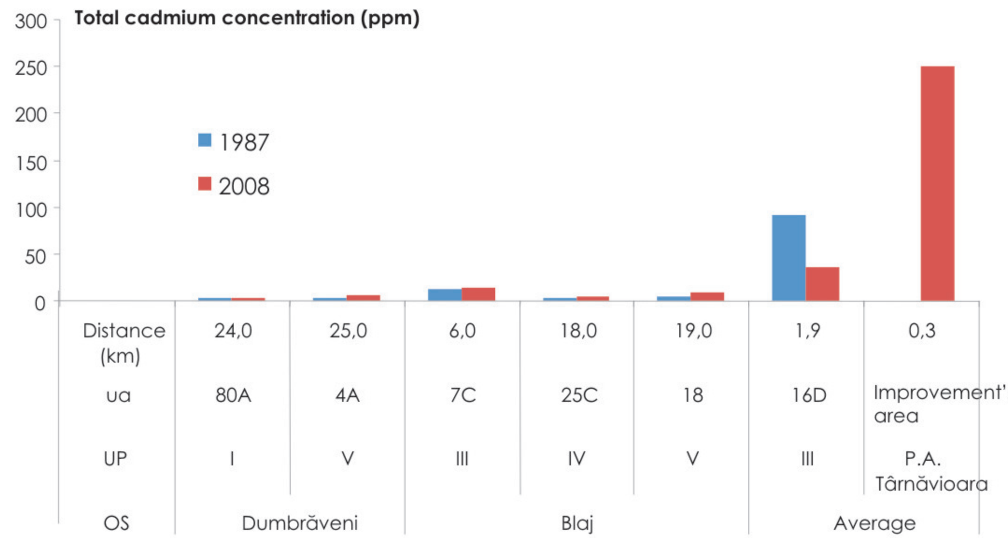

Figure 9 Dynamics of total cadmium concentration in litter samples (undecomposed leaves) from the Copşa Mică permanent plots

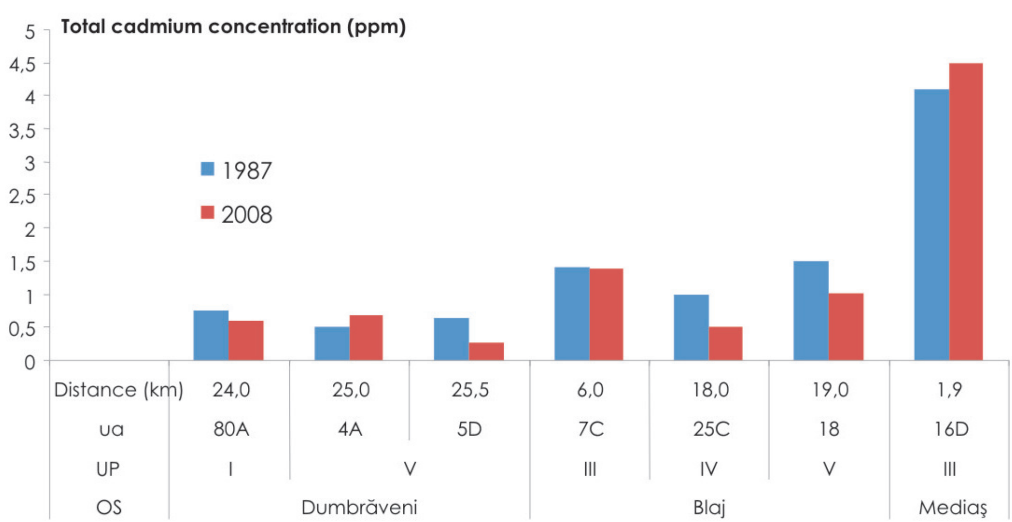

Figure 10 Dynamics of total cadmium concentration in vegetation samples of the forest stands from the Copşa Mică permanent plots

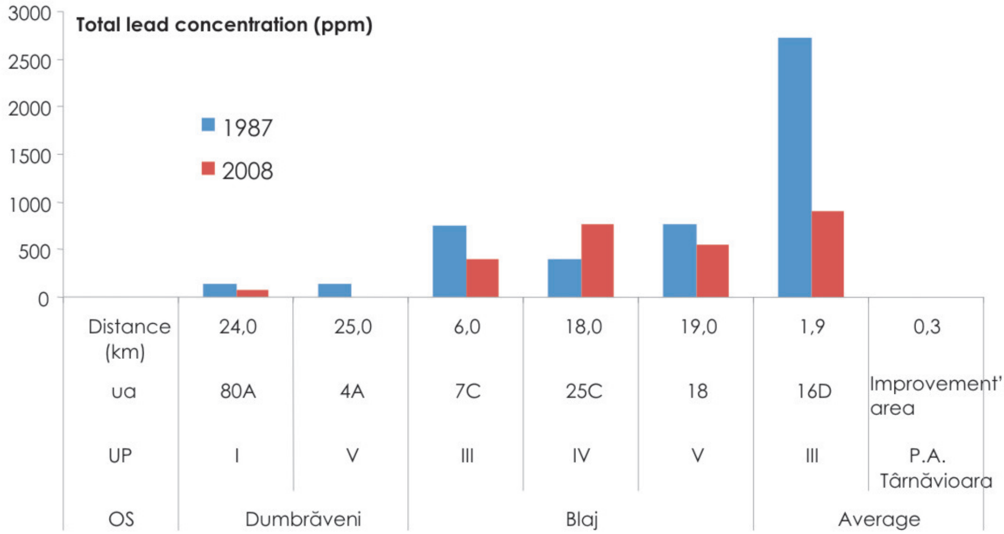

Figure 11 Dynamics of total lead concentration in litter samples (undecomposed leaves) of the forest stands from Copşa Mică permanent plots

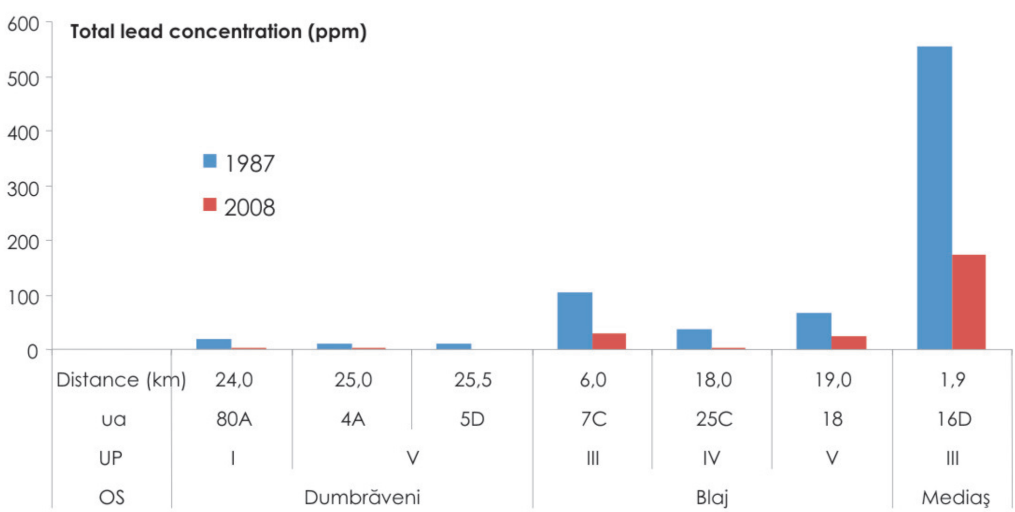

Figure 12 Dynamics of total lead concentration in vegetation samples of the forest stands, in Copşa Mică permanent plots

Table 8 Mean and maximum variation of concentrations in air, of different pollutants at Copşa Mică, in the period 1989 - 2003 (APM Sibiu)

Year	MAL ěg/m^3/24h	Total number samples	Total number of samples >MAL	% MAL overdose	Mean value in ěg/m^3 24h	Maximum value ěg/m^{3}24h	MAL overrun (over…times)
Sulphur Dioxide							
1989	250	-	-	-	-	2988	12,0
1990	250	-	-	-	-	2635	10,5
1991	250	-	-	-	-	1353	5,4
1992	250	-	-	-	-	1229	4,9
1993	250	1637	55	3,36	50	1588	6,4
1994	250	1745	11	0,63	27	338	1,4
1995	250	1797	3	0,17	22	360	1,4
1996	250	1707	7	0,41	29	698	2,8
1997	250	1686	4	0,24	30	406	1,6
1998	250	1429	0	-	18	234	
1999	250	1437	5	0,35	19	393	1,6
2000	250	2072	35	1,69	48	648	2,6
2001	250	1518	7	0.46	25	391	1.6
2002	250	-	-		17	170	-
2003	250				13	268	1,1
Pb from suspended powders							
1989	0,70	-	-	-		53.4	76,3
1990	0,70	-	-	-	-	70,4	100,6
1991	0,70	-	-	-	-	84,8	121,1
1992	0,70	-	-	-	-	42,8	61,1
1993	0,70	1058	666	62,95	2,51	59,9	85,6
1994	0,70	1353	761	56,25	1,89	29,4	42,0
1995	0,70	1423	846	59,45	2,11	24,8	35,4
1996	0,70	1382	860	62,23	2,13	36,3	51,9
1997	0,70	1197	832	69,51	1,95	52,7	75,3
1998	0,70	1349	997	73,91	2,64	46,7	66,7
1999	0,70	1434	1057	73,71	3,03	39,0	55,7
2000	0,70	1766	1237	70,05	2,32	20,3	29,0
2001	0.70	1443	817	56,62	1,82	46,3	66,1
2002	0.70	-	-	4,7-74,7	1,04	30,6	43,7
2003	0,70				2,80	25,4	36,3

that high concentrations of pollutants has been shown in soil of the studied forest stands, more protected compared with agricultural lands, certainly these concentrations are higher, especially worrying for human or animal health because Ao layer of these soils are most suitable for vegetables gardening, agricultural crops and grass on pastures and meadows.

We may ask why, considering these conditions, the area recorded a high incidence of cases of cancer and a high mortality among humans and animals. Therefore, it appears necessary to monitor the evolution of pollution and its effects on the environment, by lowering the limits on the MAL or even closing those industrial capabilities, while providing retraining for the unemployed and initiating the interdisciplinary research project under the coordination of the Academy of Agricultural Sciences and Forestry, Gheorghe Ionescu -

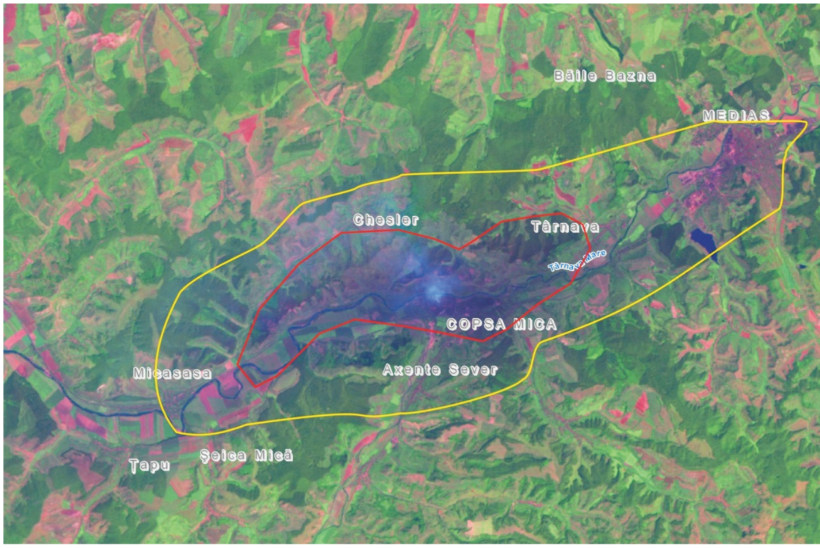

Figure 13 Landsat 5TM image, bands combination 7,4,2, at 17-08-1986. The strong damaged area is marked with red line and the medium damaged area is marked with yellow line

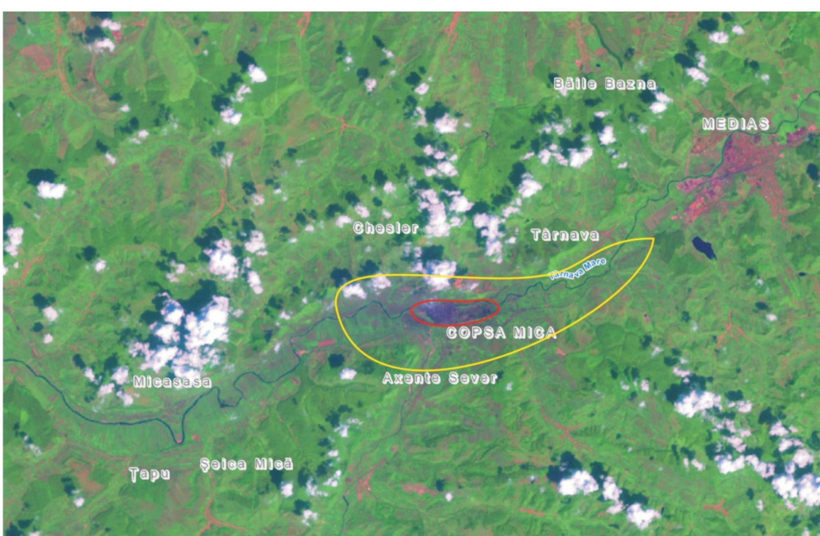

Figure 14 Landsat 7ETM+ image, bands combination 7,4,2, at 2-08-2001

Şişeşti " for finding the most effective means of decontamination of soil from the tens of thousands of hectars that otherwise would remain a particularly serious problem to human, animal and earth.

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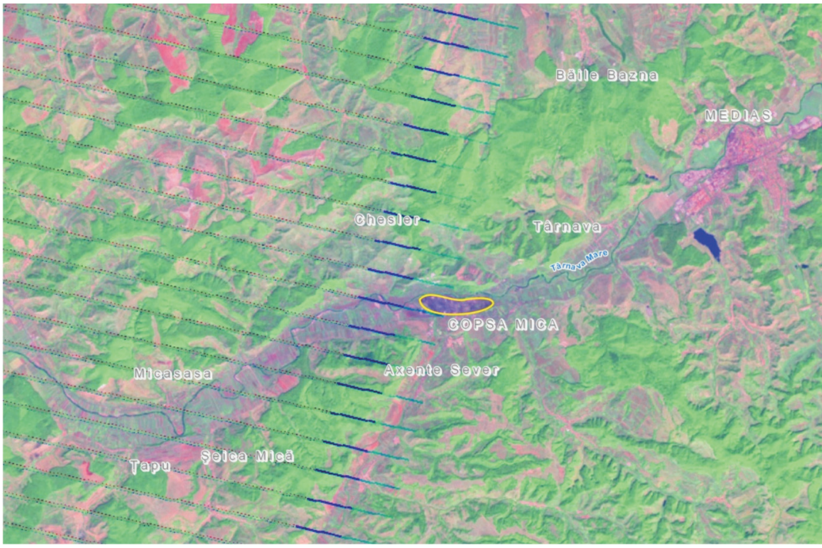

Figure 15 Landsat 7ETM+(SLC off) image, bands combination at 21-08-2008

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